12/21/78, 1420, Main & Lifford
HP 140, Whip, F 100 kHz, W 50 kHz, IF 1 kHz, ST 500 ms, RF 0 dB, IF -20 dbm

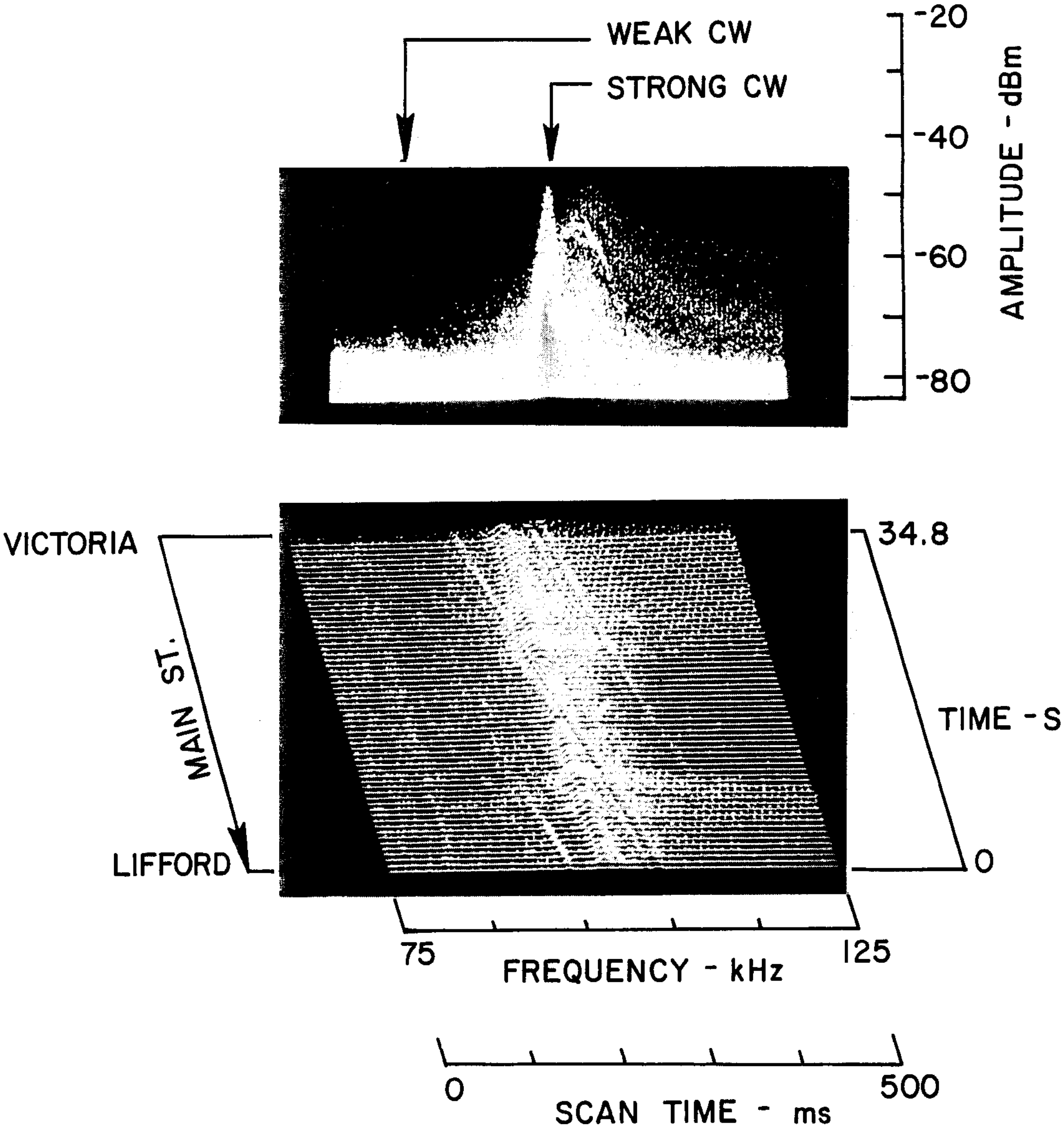
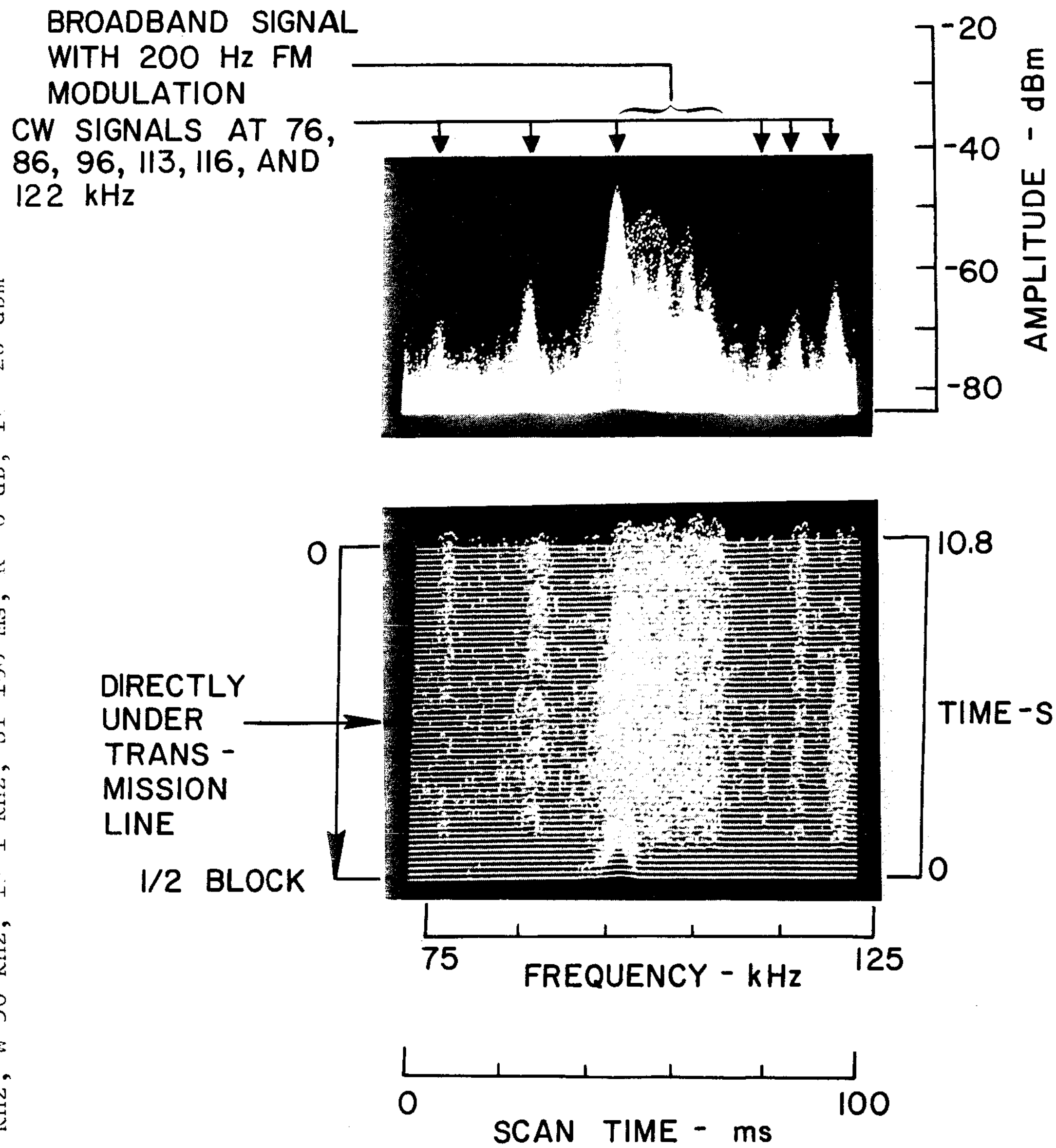


FIGURE 3-27. 12/21/78, 1420



12/21/78, 1520, N. Spring on Railroad overpass (between Aurora & 18th Ave.)
HP 140, Whip, F 100 kHz, W 50 kHz, IF 1 kHz, ST 100 ms, RF 0 dB, IF -20 dbm

FIGURE 3-28. 12/21/78, 1520

12/21/78, 1525, N. Spring on Railroad overpass between Aurora & 18th Ave.
HP 140, Whip, F 100 kHz, W 50 kHz, IF 0.3 kHz, ST 200 ms, RF 0 dB, IF -20 dbm

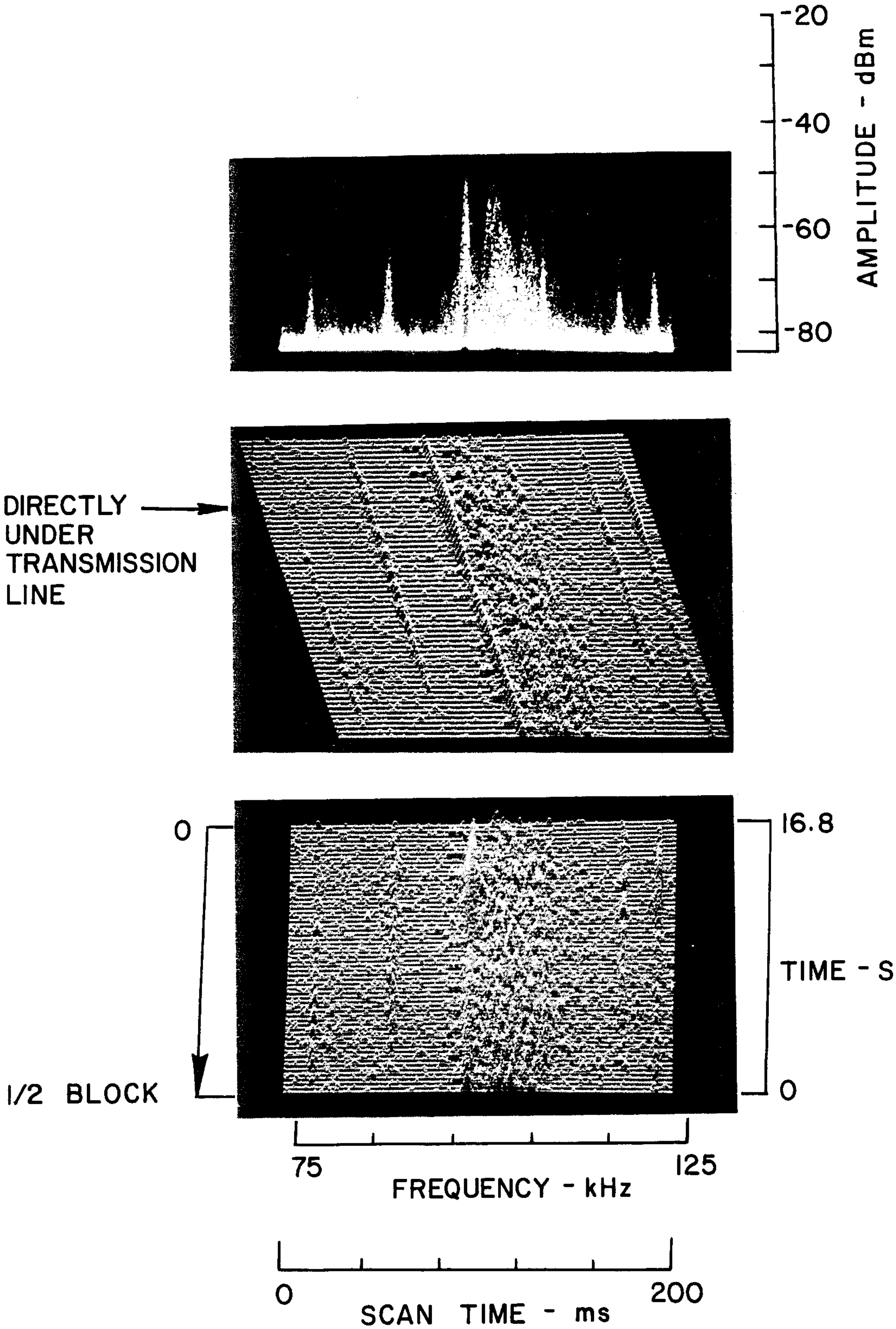


FIGURE 3-29. 12/21/78, 1525

3.8 FREEWAY RECEPTION

Reference 3-Axis Views: 12/19/78, 1611/1612 (Figure 3-30)
12/19/78, 1614/1622 (Figure 3-31)

Loran-C signal reception was briefly examined during travel between measurement sites. Generally, reception was quite good along open and elevated freeways. Occasional brief periods of noise would be encountered as the measurement van traveled by or under electric utility distribution lines containing impulsive noise. Signal fades were very noticeable as the measurement van traveled under an overpass or a large overhead highway sign. Two examples of signal fading associated with travel under an overpass are shown in the data at 12/19/78, 1611/1612. The bottom example shows a signal fade associated with an overhead highway sign which extended across the freeway.

The vertical lines shown in all views were ignition noise from the gasoline generator supplying power to the measurement system. This noise should be ignored since it was considered an unnecessary noise contaminent in some of the data.

12/19/78, 1611/1612, Harbor Freeway
HP 140, Whip, F 100 kHz, W 20 kHz, IF 3 kHz, ST 500 ms, RF 0 dB, IF -20 dbm

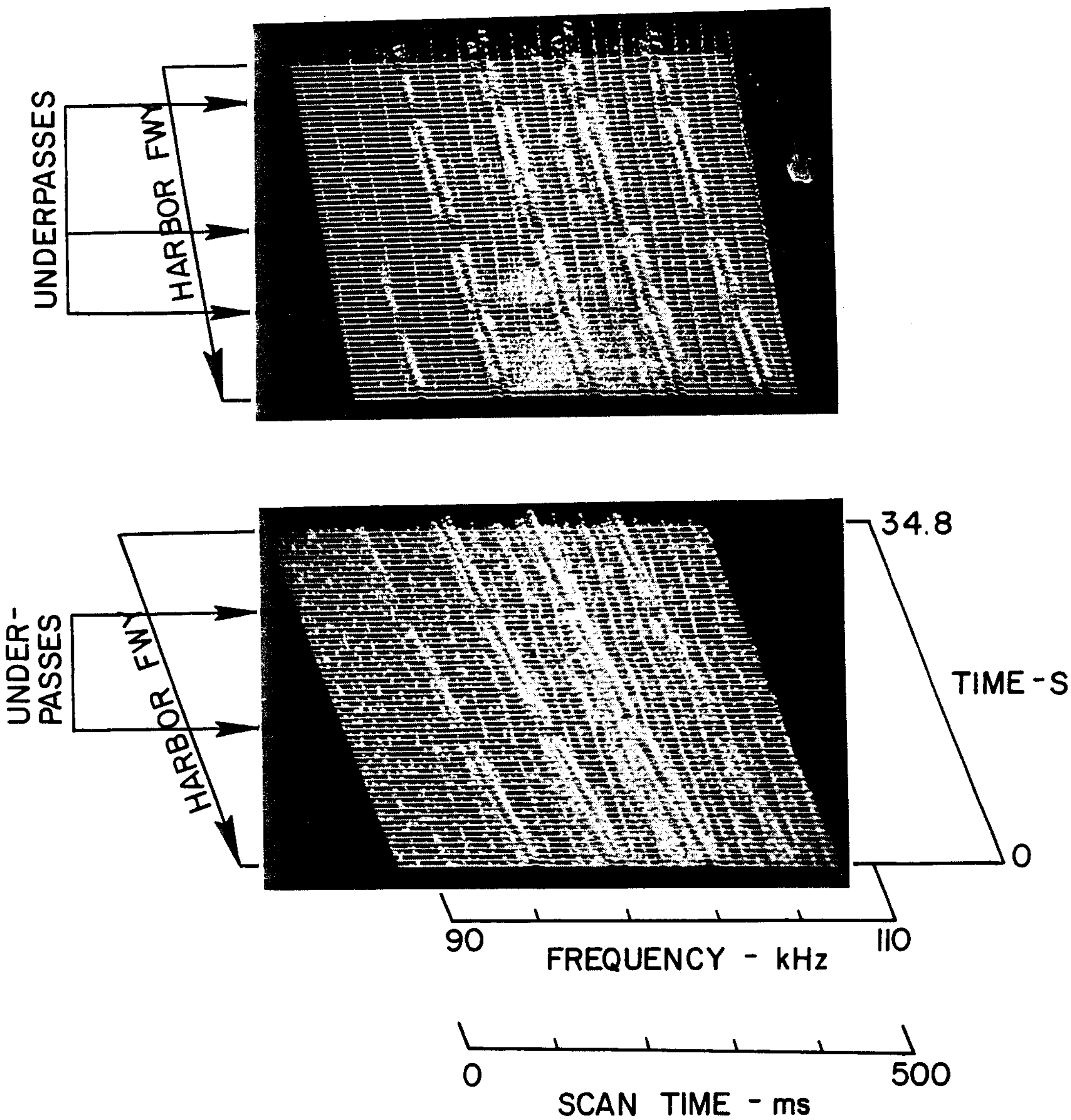


FIGURE 3-30. 12/19/78, 1611/1612

12/19/78, 1614/1622, Harbor Freeway
HP 140, Whip, F 100 kHz, W 20 kHz, IF 3 kHz, ST 500 ms, RF 0 dB, IF -20 dbm
Bottom view 50% comp

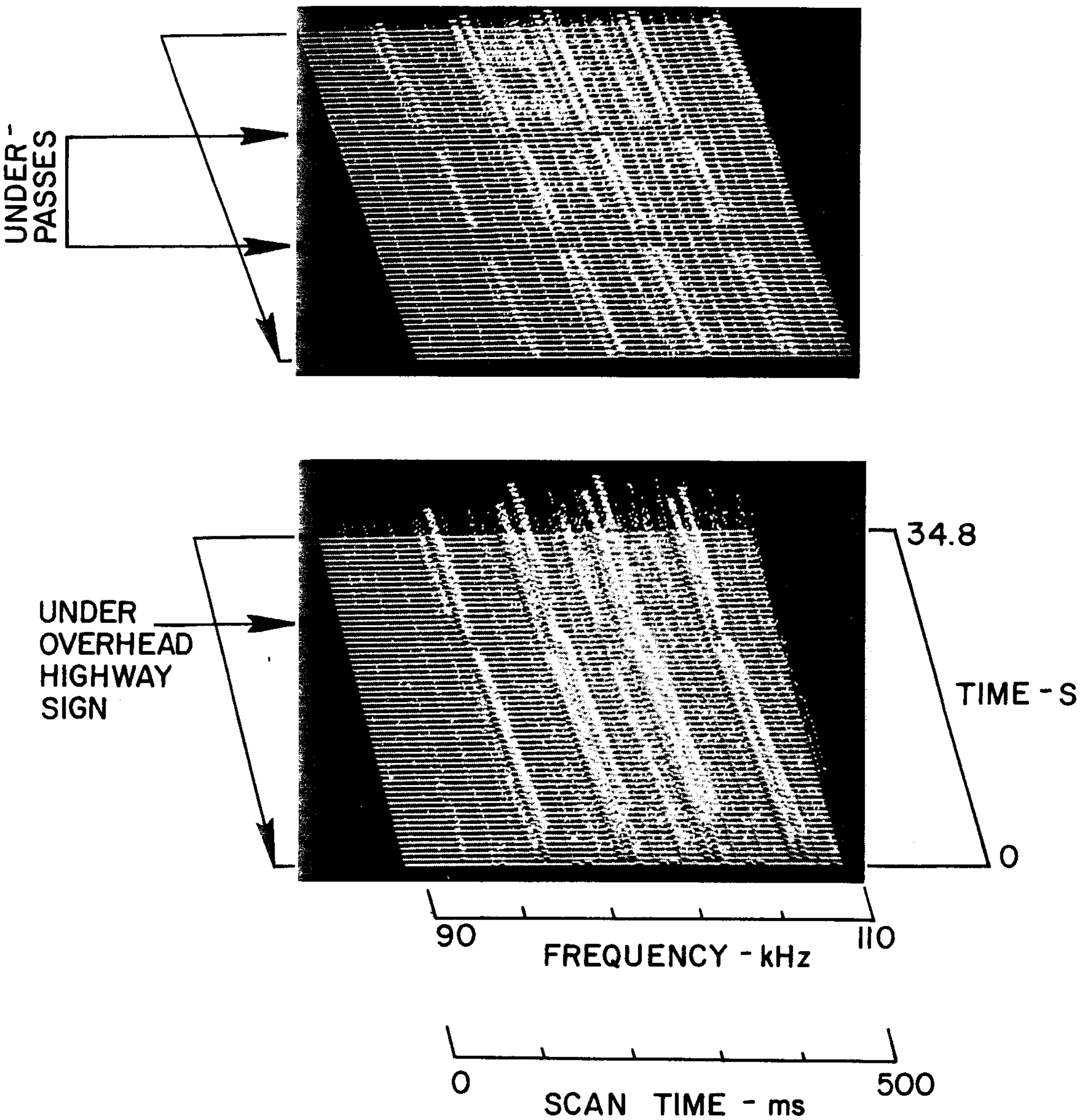


FIGURE 3-31. 12/19/78, 1614/1622

4. DISCUSSION

4.1 GENERAL COMMENTS

The identification of locations and streets where noise, RFI, or some other unusual condition existed was of significant assistance in getting noise and RFI measurements underway efficiently, and this eliminated the need to make a large scale area survey. Locations where Loran-C receiver performance degradation was experienced were critically examined, and subsequent direct comparisons of Loran-C receiver results with noise and RFI results appear to be meaningful and feasible. In general, the locations identified had noise, RFI, or combinations of both. The few locations where noise or RFI were lacking seemed to be due to the intermittent and time-changing aspects of noise rather than due to pertinent technical differences.

During the measurements modest changes in noise levels and noise characteristics were often noted. Occasionally very large changes were noted suggesting that a primary source of the noise was either turned on or off during a particular measurement. No particular patterns or particular times for noise changes were deduced from the measurements, but the site-to-site movements of the instrumentation did not provide a good means to observe time-varying changes.

4.2 NOISE FROM ELECTRIC UTILITY DISTRIBUTION LINES

The impulsive noise and the quasi-random noise (Sections 3.3 and 3.4) were always associated with overhead electric utility distribution lines. Generally the measurement van had to be close to a distribution line before the noise was of sufficient magnitude to be of concern. When the measurement van was more than about 200 feet from a distribution line, very little impulsive or quasi-random noise was found. Also, some distribution lines appeared to be entirely free of such noise. When noise was found to be emanating from a particular distribution line and the measurement van followed the line along the street, the noise was noted for many blocks. If the line left the street or if the measurement van turned off the street, the noise would immediately disappear. Noise properties were generally consistent with distance when following a given distribution line.

The timing of impulsive noise was always associated with the 60 Hz line frequency. No unusual timing reference situations were found during the one week measurement period. Very simple impulse timing patterns were found where the impulses were associated with triggering on only one-half of the 60 Hz waveform (impulses spaced each 16.6 ms) and where the impulses were associated with triggering on both halves of the 60 Hz waveform (impulses spaced each 8.3 ms). More complex impulse periods were found which appeared to be associated with the triggering of 3Ø devices or by multiple devices triggering at different locations on the power line waveform. At one location the average impulse period was about 2 ms where all impulses were repetitive and synchronized with the power line frequency.

4.3 STRONG LOCAL AREA SIGNALS

The strong local area near field signals described in Section 3.5 were quite unexpected. Their frequent occurrence and large strengths made the signals very noticeable in the 3-axis views, and of course they produced significant interference to Loran-C signals at the specific locations where such signals were found. The very small and restricted areas where such signals were found imply that the sources were low in power, small in physical size, and near field signal intercept was involved. These signals were sometimes found at street corners where traffic control devices were evident. However, they were also found on other street corners where no traffic control devices existed, and they could not be found on many corners with obvious traffic control devices. Also, they were found in residential areas. No definite association could be made between these signals and local area objects even though the actual source was at times probably less than 100 feet from the measurement van. A small hand-held loopstick with a diode detector and meter indicator would have solved the location and identification problems, but such a device was not available.

The source of many of the strong local area signals was the subject of considerable discussion and some frustration at not being able to identify an emitter obviously so close to the measurement van. Speculation about the source could not be avoided. Some of the probable sources were:

1. Traffic control devices
2. Ultrasonic burglar alarms
3. TV set radiation
4. Telephone line signals.

4.4 WEAK CW SIGNALS

Sections 3.5 and 3.6 described several weak CW signals which were present over large portions of the measurement area. The signal at 117 or 118 kHz was the most persistent, and it was present in about one-half of the data taken in Los Angeles. Its source is believed to be a distant communications transmitter. Other CW signals at 88, 100, 103, 120, 130, 140, and 150 kHz were detected at various times during the measurement period. The source of these signals was not investigated during the brief one week of the Los Angeles measurements. The measurement van was equipped with an LF direction finding capability, but this equipment was not employed during the measurement period because of a lack of time.

The weak 100 kHz signal might be far field radiation from the power carrier communications signal described in Section 3.7. This, of course, is again speculation. This can be easily verified by simple DF measurements, and coordinating with the utility involved to observe the 100 kHz signal during a brief carrier communications shut-down period.

4.5 POWER TRANSMISSION LINE CARRIER COMMUNICATIONS

One definite case of a power carrier communications signal on an electric utility high voltage power transmission line at or very close to 100 kHz was identified. The carrier communications signal rose to a level well above the strongest Loran-C signal when the measurement van was on the Artesia Freeway directly under the transmission line, and the signal was received at lower signal levels for a few blocks on either side of the line. In addition a few spikes of very high level noise were received when directly under the line. The CW signal at or near 100 kHz was also observed on other nearby streets which passed under the transmission line. However, the particular transmission line involved was not investigated at other locations nor was a map showing its routing available during the measurements. It is a reasonable assumption that the 100 kHz signal would be received at other streets and highways passing under the line.

The identification of a 100 kHz power carrier signal within an area where Loran-C had been considered for vehicular navigation purposes raises serious questions of compatibility between the two systems for a region along the length of the transmission line. This is an obvious case where frequency coordination efforts must be undertaken with the appropriate city, utility, and Federal government agencies and officers. However, immediate and rapid resolution of the issue appears to be unnecessary since the area affected is limited and does not involve major portions of Los Angeles of immediate concern for Loran-C.

A second case of signals somewhat like power carrier signals was identified near North Spring and 18th Avenue where a high voltage transmission line crossed North Spring. However, extensive railway and telephone communications facilities were also found in the same vicinity. The mobile instrumentation employed during the week's measurement period could not resolve the actual source of these signals. While they are listed under the power carrier section (Section 3.7), additional measurements with directional near field probes and measurements at other locations under the transmission line will be required to identify their specific source.

4.6 SPATIAL CONSIDERATIONS

Most of the impulsive noise, quasi-random noise, and strong CW signal RFI were limited to a large number of very small geographic areas whose limits were surprisingly well defined. These areas were obviously associated with noise and RFI radiation mechanisms which were located very close to the noise or RFI maximum, and near field signal reception conditions were obviously involved in most of the noise and RFI situations. If an overhead transmission line containing impulsive current extended along a given street, then noise was found along that street. If the affected line was approached from a cross street, the noise level rapidly increased as the line was approached and rapidly decreased as the vehicle moved away from the line. Noise was no longer observed at distances of 100 feet to 200 feet from an affected line.

Similar near field signal reception conditions applied to the strong CW RFI. The strong signal areas were very small in physical size, and these areas were usually surrounded by larger areas of extremely low noise or noise of an entirely different type.

The very small physical areas containing high noise and RFI levels suggest that terrain maps of the noise and RFI must be made on an extremely fine scale in order to be meaningful in understanding the radio environment encountered by Loran-C receivers installed in vehicles. Cases were found where a street with high noise levels would be paralleled by another street one block away which was virtually free of noise. Gross terrain mapping techniques cannot realistically represent such situations.

Alternate noise and RFI mapping approaches must be considered to describe the Los Angeles area in sufficient detail to permit relating actual noise to Loran-C receiver performance. Some approaches which might adequately describe the spatial aspects of noise and RFI are:

1. Measure and define noise along specific streets of interest and do not apply these results to other nearby streets.

2. Map the electric utility overhead distribution lines and then measure and rate each section of line with a noise value related to vehicular Loran-C receiver performance.

Any noise mapping scheme will be plagued by the time-changing characteristics of noise emanating from a particular distribution line. Noise on the line will vary as customers change their loads, add new loads, expand their operations, go out of business, move, etc. The electric utilities can change noise conditions on a given street by changing the configuration of their distribution network to accommodate normal demands for electric service. These aspects of noise and RFI suggest that today's noise map may not apply to tomorrow's vehicular Loran-C needs.

4.7 NOISE SOURCES AND POSSIBLE CONTROLS

The actual devices causing the impulsive noise are believed to be various high power switching devices employed by small, medium, and large size industry for electrical and industrial controls. These high power switching devices suddenly turn current on at some reference point on the power line voltage waveform. Very high currents, typically hundreds of amperes, flow at the switching time and the switching impulses propagate back into the local area distribution lines. Initial measurements of the impulse propagation back into distribution lines from specific identified sources have been made under other work tasks by Systems Control, Inc. The Los Angeles data are very similar to these prior results.

Actual devices causing the Los Angeles measured impulse noise were not tracked down and traced to specific industries or other sources. The mobile type of Los Angeles measurements described in this report were not sufficient to identify the actual sources. However, source identification measurements are feasible, and they can be accomplished with slightly different instrumentation arrangements. Many sources distributed among many electric utility customers are undoubtedly involved. While electric utility hardware, distribution lines, and devices seem to be the transporting mechanism of the impulses and their radiator, the electric utilities do not originate the noise.

Filtering at the source appears to be the most logical technical solution. However, it is not clear how one would establish technical specifications for filters for the offending devices, how one would implement a program to install expensive filters, or who would pay for the filters. A short term solution would be extremely difficult to achieve. A long term solution would require considerable coordination among industry, the manufacturers of the source equipments, public utilities, Loran-C interests, and the appropriate government agencies involved with radio spectrum management.

The high level CW signals found at many locations can be traced to their radiator with a small loopstick-detector-meter indicator type device. The identification of the radiating device will undoubtedly lead to the actual source device. Only after the source devices are identified can suitable control recommendations be formulated.

The weak CW signals can be traced to their sources by employing tuned loopstick antennas with preamplifiers in place of the 108 inch whip employed in the Los Angeles measurements. The tuned loopstick antennas can be rotated to identify the direction of arrival of each signal. Measurements at several separate locations will provide sufficient data to ascertain if the signals originate from sources outside Los Angeles or sources inside Los Angeles. If any of the sources are inside Los Angeles, then close-in measurements can be used to identify the specific radiator involved.

4.8 LORAN-C SIGNAL RECEPTION

Loran-C station Y of the U.S. West Coast Chain (Searchlight, Nevada) provided a very strong signal throughout most of Los Angeles. Exceptions were in downtown Los Angeles among nearby tall buildings and when the measurement vehicle was in a road underpass. Minor signal fades of Y were noted when the measurement van passed under overhead wires, signs, cables, and other structures. The Y signal was above power line associated noise levels except for a few unusual noise situations. However, the local area CW signals often approached the level of station Y for perhaps $\pm$ 50 feet along a street. Frequently these high strength areas were at street corners.

Station X (Middletown, California) provided a reasonable signal over most of the test area with the exception of downtown Los Angeles and underpasses. The signal was above noise levels throughout large portions of the test areas, but the signal-to-noise levels were considerably lower than for station Y.

The Loran Y Master station (Fallon, Nevada) signal was adequate for operation under ideal conditions where buildings, underpasses, or noise were not involved. However, most noise sources exceeded the Master signal level and at times exceeded the signal level by very large amounts. Master station signal level increases will be necessary to cope with the radio noise and RFI environment of Los Angeles. An increase in level of at least 10 dB is recommended.

5. PRESENTATION OF SIGNIFICANT DATA

5.1 GENERAL APPROACH

The first phase of a field measurement effort to investigate and ascertain the performance of Loran-C receivers installed in land vehicles was conducted in late 1978 in the Los Angeles area. These measurements identified certain streets, street intersections, and areas where unusual radio noise and RFI conditions existed. The noise and RFI at selected locations and along selected streets was examined in detail by Systems Control, Inc. (SCI) in December of 1978, and the noise and RFI conditions described in Sections 3 and 4 of this report.

The late 1978 measurements of Loran-C receiver performance in the Los Angeles area were continued into early 1979 at additional locations and areas not previously examined. During the week of January 22 through January 26, 1979, the SCI radio noise and RFI measurement van accompanied the Gould Inc. mobile Loran-C receiver measurement van to a number of sites selected by Gould Inc. personnel. The sites selected were typical of expected operational areas for municipal vehicles and other vehicles which might be equipped with Loran-C navigation systems at some future time. Loran-C receiver performance measurements were made at each selected site simultaneously with measurements of radio noise and RFI by SCI. The noise and RFI measurements are presented in this section.

In addition to measurements at predetermined sites, supplementary measurements of noise and RFI were made while traveling from site to site, at locations close to the fixed sites, and at additional locations of special interest. The results of these supplementary measurements are also presented in this section.

The noise and RFI measurements described in Sections 3 and 4 employed a bandpass filter in the matching network between the antenna and the preamplifier. The use of the filter required that a bandwidth calibration factor be applied to the amplitude of signals and noise below about 90 kHz and above about 110 kHz. The filter was used to ensure that strong CW signals and wideband noise would not saturate the preamplifier and cause unwanted intermodulation products to appear in the 3-axis views. The filter was successful in that intermodulation products were not encountered in the Phase I measurements. An alternate preamplifier with a wideband filter was constructed for the Phase II measurements. The preamplifier with the wideband filter was employed for most of the Phase II measurements, although some of the early measurements and some measurements in areas where high level, wideband power line noise was encountered were made with the Phase I narrowband unit. Data taken with the narrowband filter are clearly labeled.

5.2 FIXED SITE MEASUREMENTS

An extensive geographic survey of the greater Los Angeles area had been completed prior to the Phase II effort. From this survey a number of sites were selected for detailed measurements of Loran-C receiver performance and for radio noise and RFI measurements. The site identification numbers and site categories have been used in this section to simplify the task of comparing the results of the two measurements.

A three-letter code was used to identify the particular municipal areas selected for joint measurements. This code was followed by three additional numbers which identified the sites selected for measurements. The municipal area codes are given in Table 5-1. Table 5-2 provides a convenient summary of the measurement locations, site identification numbers, the general activity in the vicinity of each site, the heading of the measurement van along the street, and the presence or absence of nearby electric utility power lines.

TABLE 5-1. IDENTIFICATION NUMBERS FOR MUNICIPAL AREAS

Municipal Area	Identification #
El Segundo	104
Torrance	106
Southgate	107
Compton	108
Carson	109
Lincoln/Boyle HTs	110

TABLE 5-2. LORAN-C SITE SURVEY DATA

	SITE ID #	STREET INTERSECTION*	SITE CATEGORY**	MEAS. VAN HEADING	POWER LINES†
REGION 6 TORRANCE	106-001	Artesia/Van Ness	C	W	1
	106-002	178th/Falda	R	W	0
	106-003	182nd/Crenshaw	C	E	1
	106-004	190th/Prairie	I	E	2
	106-005	Fisk/Spreckels	R	S	0
	106-006	Redbeam/Towers	R	N	0
	106-007	Anza/Torrance	C	N	1
	106-008	Maricopa/Madrona	O	N	0
	106-009	Crenshaw/Dominguez	I	N	1
	106-010	Del Amo/Crenshaw	I	E	2
REGION 9 CARSON	109-011	182nd/Wall	R	S	0
	109-012	192nd/1800' west of Avalon	O	E	0
	109-013	Dominguez/Avalon	C	E	0
	109-014	Carson/Orrick	C	W	1
	109-015	Avalon/223rd	C	S	1
	109-016	Wilmington/Sepulveda	I	N	1
	109-017	Sepulveda/Alemeda	I	W	2
	109-018	Watson Center/Wilmington	I	E	0
	109-019	Tillman/Denwall	R	N	0
	109-020	Brenner/Annalee	R	W	0

* Intersection shows location of van as first street listed (i.e., 3rd/Vine = van on 3rd).

** Site category: C - commercial, R - residential, I - industrial, O - open.

† Power lines show number of lines present (one side or both sides of street): 1 - one side, 2 - both sides, underline of number - van directly under lines.

TABLE 5-2. LORAN-C SITE SURVEY DATA (CONTINUED)

	SITE ID #	STREET INTERSECTION*	SITE CATEGORY**	MEAS. VAN HEADING	POWER LINES†
REGION 8 COMPTON	108-021	Wilmington/Walnut	I	N	_1_
	108-022	Acacia/Carob	I	S	0
	108-023	Compton College Parking Lot (500' north of Artesia/west of Delta)	O	S	0
	108-024	Johnson/Alemeda	I	E	_1_
	108-025	Tichenor/Oleander	R	W	1
	108-026	Mayo/Myrrh	R	N	0
	108-027	N. Sloan/E. Palmer	R	S	1
	108-028	Rosecrans/Santa Fe	C	E	0
	108-029	Rosecrans/Matthisen	C	W	_1_
	108-030	Alondra/Wilmington	C	E	1
REGION 7 SOUTHGATE	107-031	Rayo/Firestone Pl.	I	S	1
	107-032	Firestone Blvd/Atlantic (on Dorothy 400' north)	C	W	1
	107-033	Dorothy/Firestone Blvd.	I	E	1
	107-034	Otis/Ardmore	I	N	_2_
	107-035	State/Firestone Blvd.	C	S	0
	107-036	Tweedy/State	C	E	0
	107-037	Sequoia/Mariposa	R	E	0
	107-038	San Gabriel/Tenaya	R	S	0
	107-039	Kauffman/Duane	R	N	0
	107-040	Parking lot northeast of Hildreth/Duane	O	W	0

* Intersection shows location of van as first street listed (i.e., 3rd/Vine = van on 3rd).

** Site category: C - commercial, R - residential, I - industrial, O - open.

† Power lines show number of lines present (one side or both sides of street): 1 - one side, 2 - both sides, underline of number - van directly under lines.

TABLE 5-2. LORAN-C SITE SURVEY DATA (CONTINUED)

	SITE ID #	STREET INTERSECTION*	SITE CATEGORY**	MEAS. VAN HEADING	POWER LINES†
REGION 10 LINCOLN/BOYLE HEIGHTS	110-041	Terrace Heights/Penrith	R	W	0
	110-042	4th/Soto	C	E	$\underline{1}$
	110-043	Evergreen Cemetary at Evergreen/Michigan	O	N	0
	110-044	St. Louis/Michigan	R	S	1
	110-045	Murchison/Lancaster	C	N	1
	110-046	Soto/Multnomah	I	N	$\underline{1}$
	110-047	Mission/N. Broadway	C	S	$\underline{2}$
	110-048	Zonal/Griffin-Mission	I	W	1
	110-049	Gallardo/Mission (bottom of bridge)	I	S	0
	110-050	Kearney/Pennsylvania	R	E	1
REGION 4 EL SEGUNDO	104-051	Flournoy/36th	R	W	1
	104-052	Rosecrans/Highland	C	W	1
	104-053	Parking lot west of Grand/Vista Del Mar	O	E	0
	104-054	Mariposa/Loma Vista	R	E	1
	104-055	Whiting/Holly	R	N	0
	104-056	Eucalyptus/Grand	C	S	$\underline{1}$

* Intersection shows location of van as first street listed (i.e., 3rd/Vine = van on 3rd).

** Site category: C - commercial, R - residential, I - industrial, O - open.

† Power lines show number of lines present (one side or both sides of street): 1 - one side, 2 - both sides, underline of number - van directly under lines.

Three special sites were selected for daily measurements of Loran-C receiver performance. These sites were the Los Angeles Coliseum, Broadway and Pico, and the Los Angeles Municipal Transportation Authority Building at 425 Main Street. Figures 5-1 and 5-2 show typical conditions at the Los Angeles Coliseum. Very little radio noise was encountered, but three CW signals of modest strength and two weak CW signals are shown in the 3-axis views taken on 1/24/79 and 1/26/79. The relative amplitudes of each of the received signals at the Coliseum with all calibration factors applied are:

Frequency	Approximate Level
80 kHz CW	-86 dBm
90 kHz CW	-80 dBm
100 kHz CW	-86 dBm
108 kHz CW	-105 dBm
119 kHz CW	-80 dBm
Loran M	-78 dBm
Loran W	<-93 dBm
Loran X	-73 dBm
Loran Y	-63 dBm

Figure 5-3 illustrates RFI conditions at Broadway and Pico. The 100 kHz CW signal increased in level substantially over that observed at the Coliseum site, while the 80 kHz and 90 kHz CW signals were much lower in level. Impulsive noise was not present. The relative amplitudes of each of the signals in the 3-axis view are:

Frequency	Approximate Level
80 kHz CW	-88 dBm
90 kHz CW	-90 dBm
100 kHz CW	-76 dBm
108 kHz CW	-92 dBm
119 kHz CW	-80 dBm
Loran M	<-93 dBm
Loran W	<-93 dBm
Loran X	-70 dBm
Loran Y	-63 dBm

1/24/79, 0730, Coliseum
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

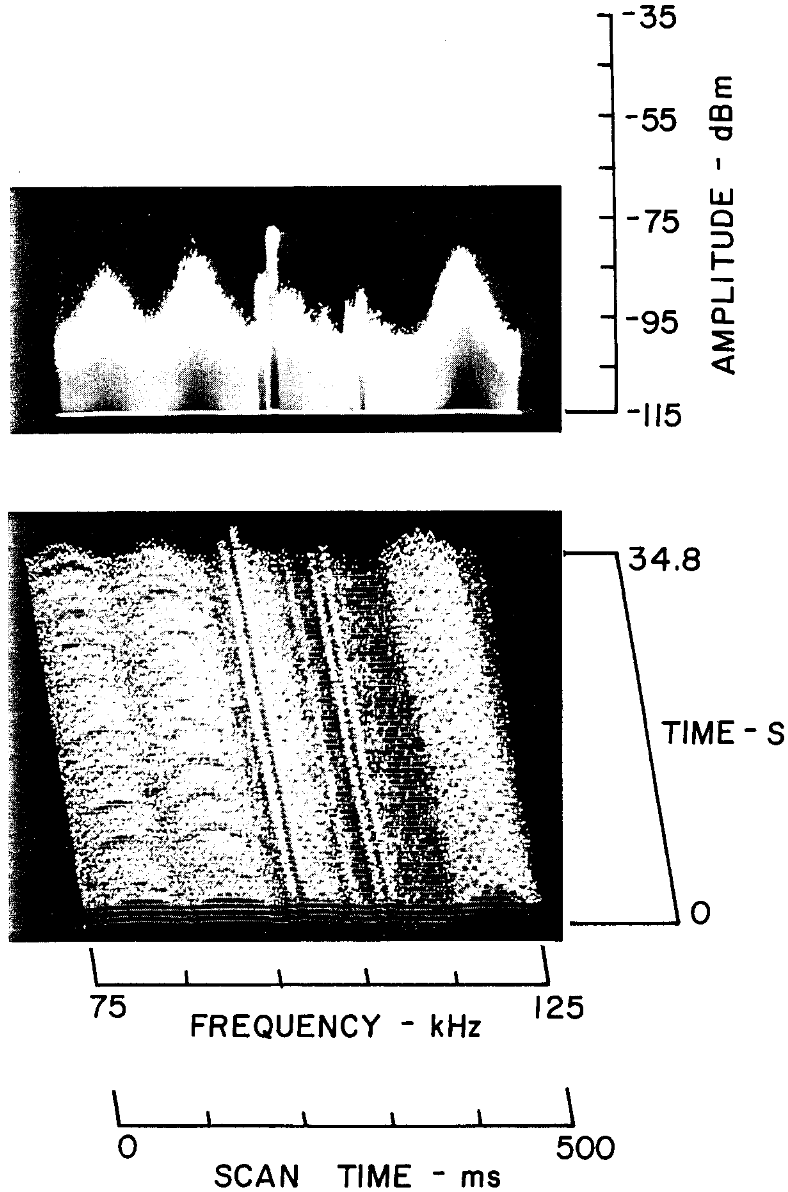


FIGURE 5-1. 3-AXIS VIEW, 1/24/79, 0730, COLISEUM

1/26/79, 0748, Coliseum
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

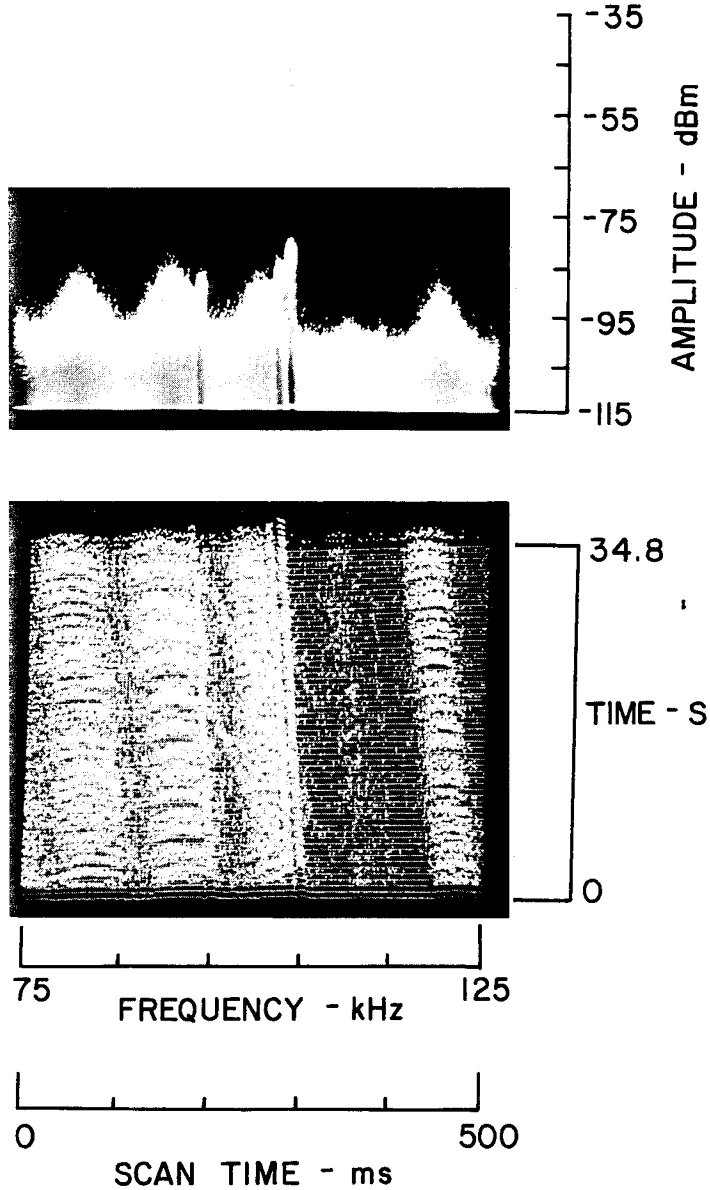


FIGURE 5-2. 3-AXIS VIEW, 1/26/79, 0748, COLISEUM

1/24/79, 0715, Broadway & Pico
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

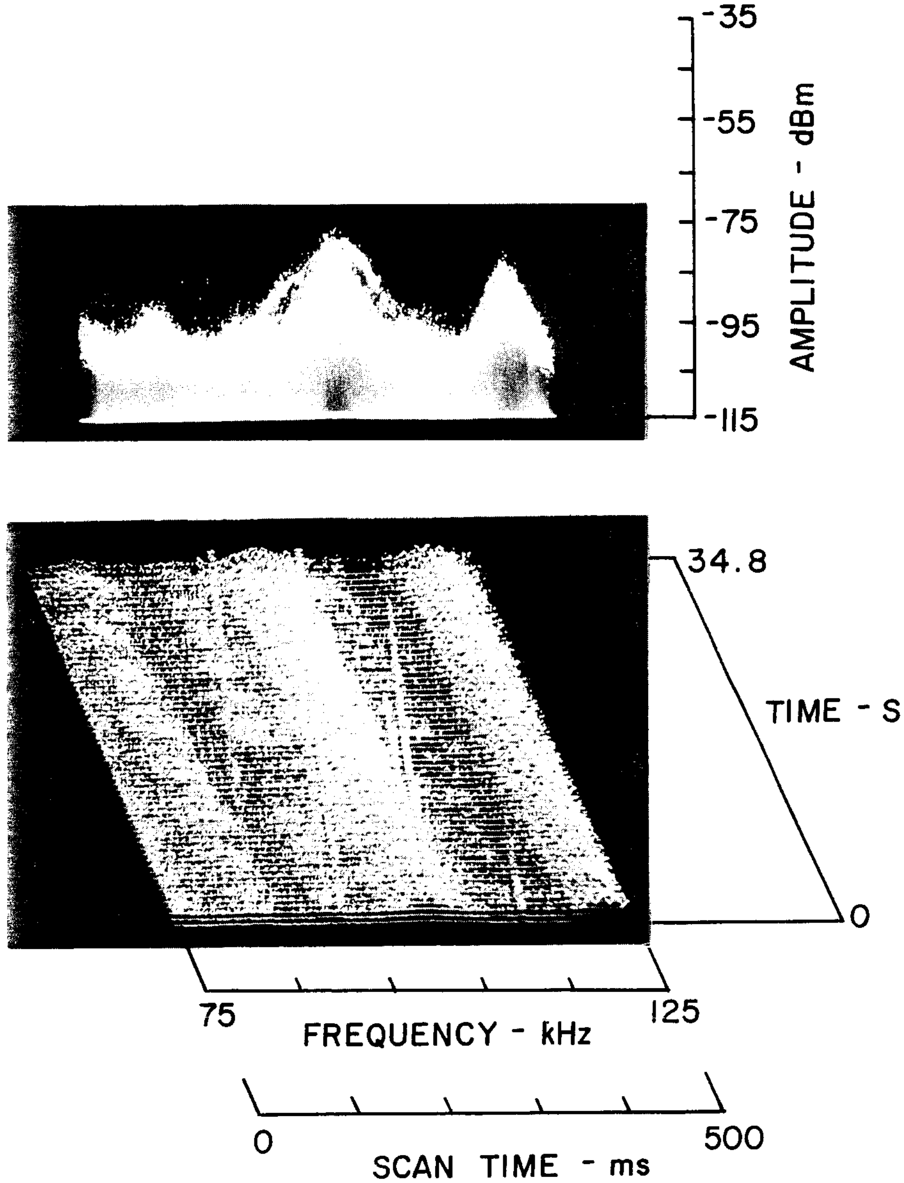


FIGURE 5-3. 3-AXIS VIEW, 1/24/79, 0715, BROADWAY AND PICO

Figure 5-4 illustrates signal reception at 425 Main Street, a site immediately adjacent to a large multiple story building. Neither CW nor Loran-C signals could be detected at the site, and noise levels were the lowest of all sites measured in the Los Angeles area. The nearby building obviously became part of a physical structural arrangement that severely attenuated all LF radio signals.

Loran-C, radio noise, and RFI at the various sites selected for detailed examination are shown in a sequence of fully calibrated 3-axis views in Appendix A. A pair of views were taken at each location with fixed scanning receiver adjustments of F = 100 kHz, W = 50 kHz, IF = 3 kHz, and ST = 500 ms. Where unusual conditions existed, additional views were taken using other receiver adjustments. These additional views follow the standard views, and they contain the same site identification code as the standard view. The time of day and some of the receiver adjustment parameters will be changed. These differences can be seen in the two-line set of parameters on each pair of views.

The reader can scan through the 3-axis views in Appendix A to observe the changes in noise, RFI, and Loran-C signal levels from site to site. The variety of noise and RFI from site to site is impressively diverse. This variety clearly warns against making simplistic conclusions concerning the noise and RFI. Furthermore, the wide variety of conditions suggests that average values of noise and average RFI states by themselves have little meaning.

1/24/79, 1353, 425 Main St.
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

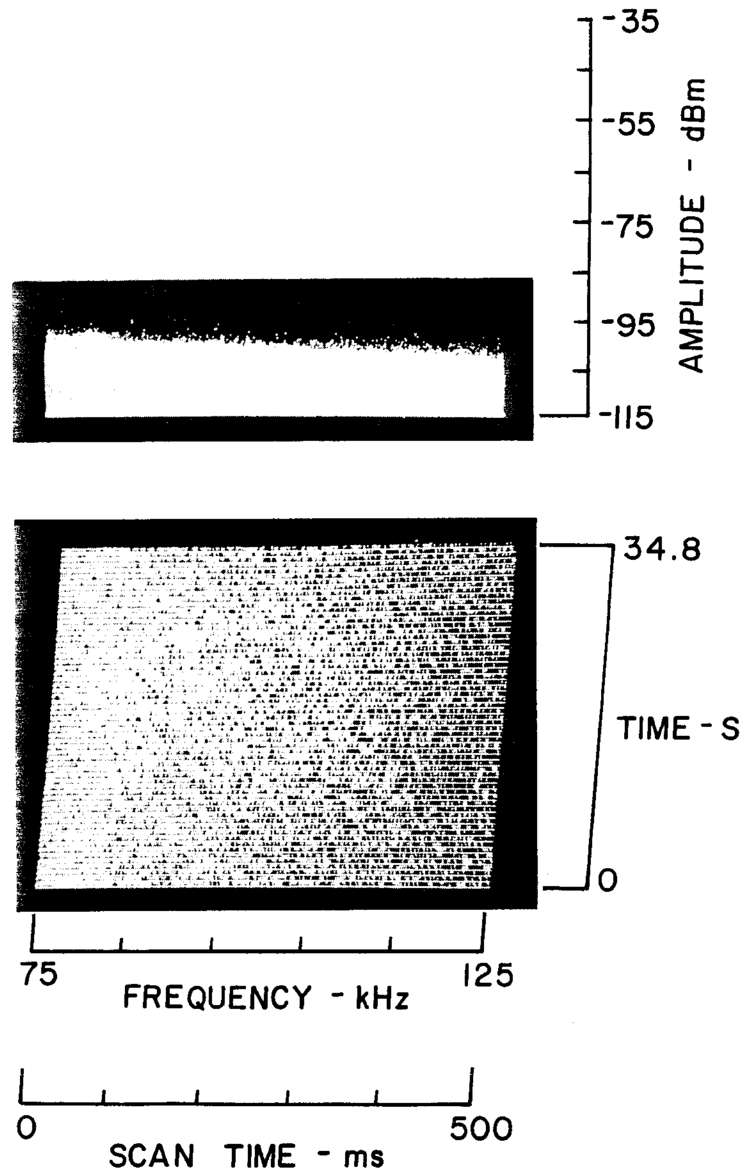


FIGURE 5-4. 3-AXIS VIEW, 1/24/79, 1353, 425 MAIN STREET

5.3 SUPPLEMENTARY MEASUREMENTS

5.3.1 General Description

The Phase I measurements showed that noise and RFI conditions frequently and usually changed over very short distances. Signal and noise levels were shown to vary in peak level by more than 40 dB over distances of less than 100 feet. Such variations would not be evident from the fixed location type of measurements described in Section 5.2 and Appendix A. Thus, as time permitted, additional measurements were made while approaching and leaving the fixed sites and at other sites of special interest. These measurements were made to provide a more complete understanding of the spatial characteristics of the noise and RFI.

5.3.2 Spatial Variations in CW Signal Levels

The 3-axis views in Figures 5-5 through 5-8 show typical variations in CW field strength as the measurement van moved along a street. Figure 5-5 shows four CW signals varying in amplitude as site 106-010 was approached. Amplitude variations of 10 to 30 dB can be seen in the view where the CW frequencies are about 80, 100, 108 and 119 kHz. This view can be compared with the 3-axis view of site 106-010 in Appendix A where the 100 kHz signal is very weak, and the 108 and 119 kHz signals are a few dB higher in strength.

Another example of large variations in CW signal strength is shown in Figure 5-6. The view was taken about 200 feet from site 109-014, and it shows a very sudden decrease in strength of a CW signal at about 88 kHz, while the signal at about 118 or 119 kHz remained constant in amplitude. The 88 kHz signal was not visible in the view for site 109-014 in Appendix A. The view in Appendix A also indicates mild impulsive noise across the entire 50 kHz block of frequencies shown.

Figure 5-7 shows an abrupt change in CW signal levels as the measurement van turned off Sepulveda onto Wilmington. Both 3-axis views shown in Figure 5-7 contain the same data at different viewing aspect angles. Weak CW signals at 80 and 90 kHz did not change in signal level, while the 100 kHz signal decreased in strength and the 119 kHz signal increased in strength. Merely turning around the corner resulted in substantial changes in the CW signal environment.

Figure 5-8 shows a change in CW signal and noise environment noted as the measurement van moved along Wilmington. The two portions of the view were taken at locations about 1/2 mile apart. The 80 and 90 kHz CW signals increased in amplitude by a small amount, and the 119 kHz signal decreased in level. A 100 kHz signal can be seen in the lower portion of the view but not in the upper portion. Impulsive noise was present at the second site, as shown in the lower portion of the view, but not at the first site, as shown in the upper portion.

HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

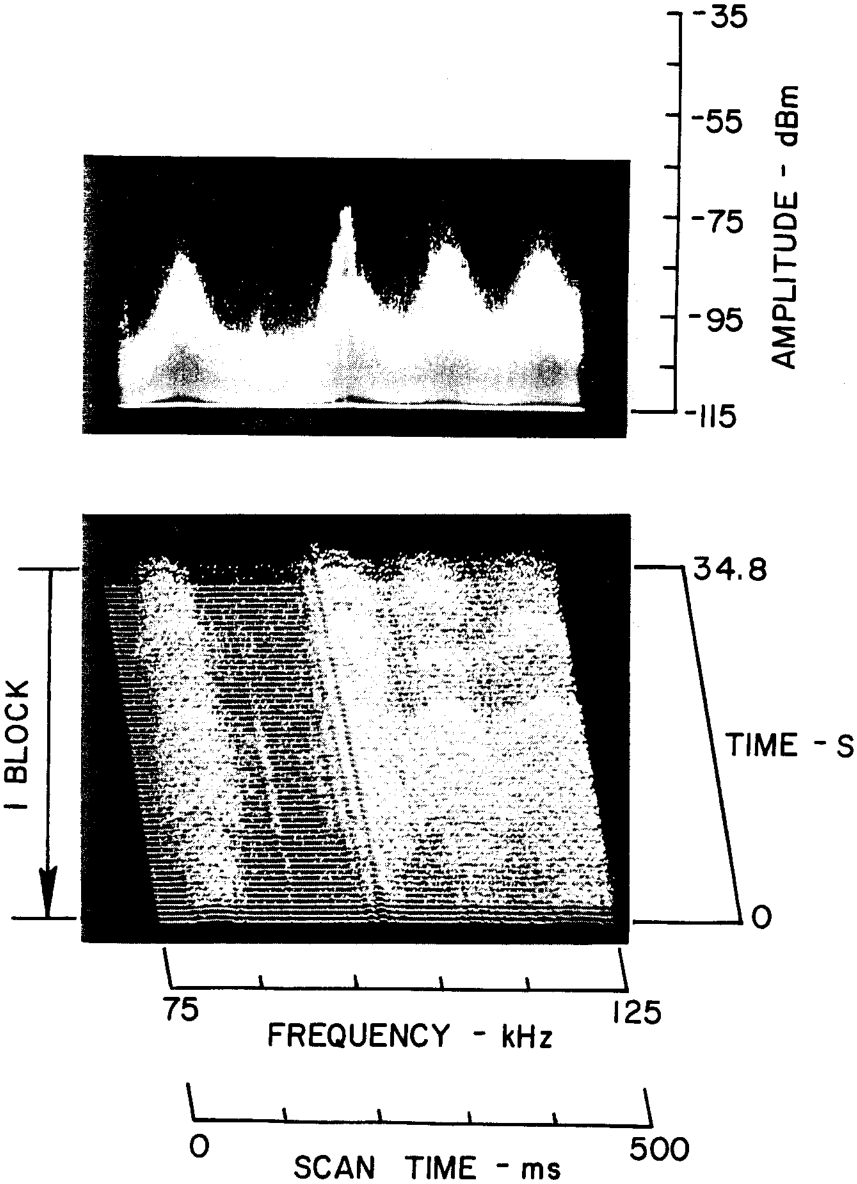


FIGURE 5-5. 3-AXIS VIEW, 1/22/79, 1220, APPROACHING 106-010

1/23/79, 0827, leaving 109-014
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

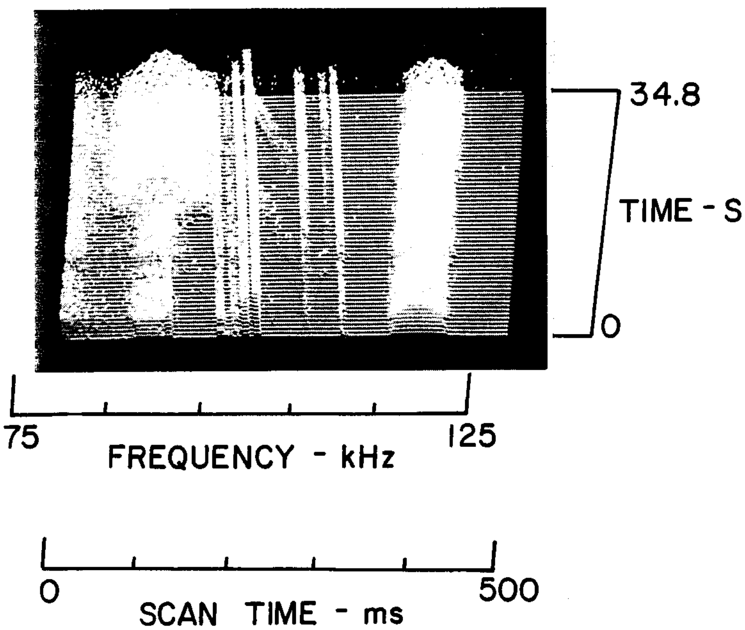


FIGURE 5-6. 3-AXIS VIEW, 1/23/79, 0827, LEAVING 109-014

1/23/79, 0916, from Sepulveda onto Wilmington
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

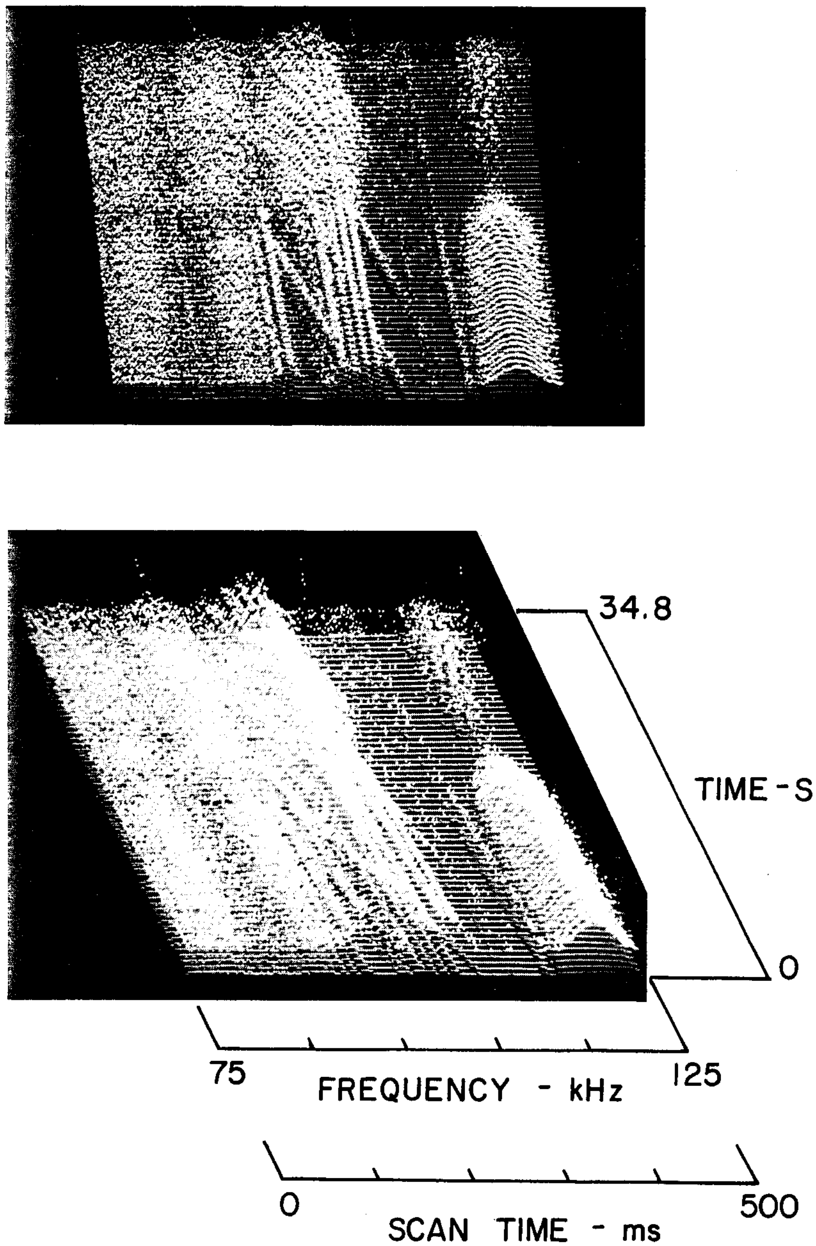


FIGURE 5-7. 3-AXIS VIEW, 1/23/79, 0916, FROM SEPULVEDA ONTO WILMINGTON

1/23/79, 0918, two locations on Wilmington 1/2 mile apart
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

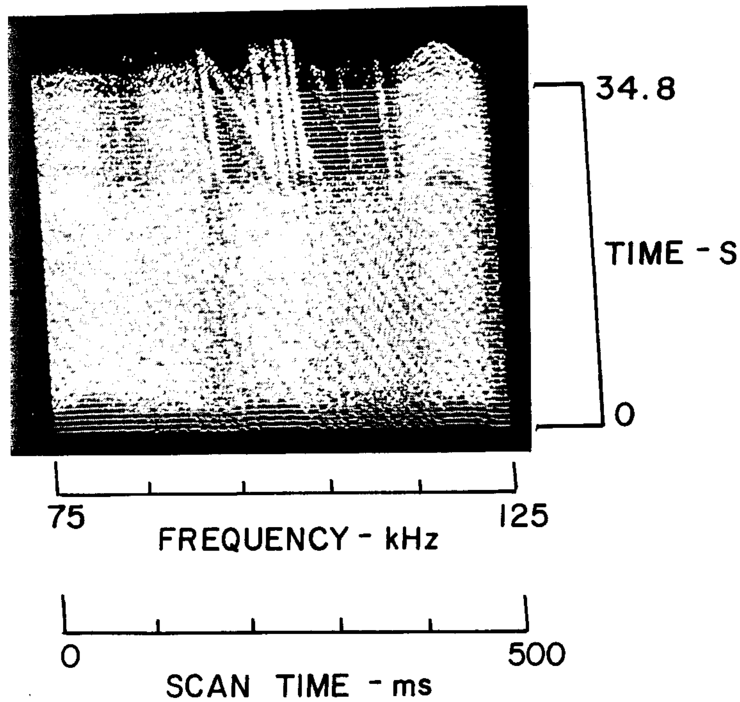


FIGURE 5-8. 3-AXIS VIEW, 1/23/79, 0918, TWO LOCATIONS ON WILMINGTON

5.3.3 Spatial Variations in Impulsive Noise

Results of the Phase I measurements showed that large changes occurred in impulsive noise levels as the measurement van approached and departed from the vicinity of certain electric utility distribution lines. The source of the impulsive noise was believed to be high power control units containing solid state switching devices employed by utility customers. Similar cases of spatial variation were also observed during the Phase II measurements.

A very large and sudden change in impulsive noise levels can be seen in Figure 5-9 where the measurement van turned off Del Amo onto Tillman. The very strong impulsive noise along Del Amo completely disappeared in less than 100 feet of travel on Tillman. The peak amplitude of the noise changed more than 70 dB in strength from Del Amo to Tillman. Another view of the impulsive noise on Del Amo is shown in Figure 5-10 at the corner of Del Amo and Anza. The noise along Del Amo at Anza was about 25 dB below the very high level at Del Amo and Tillman.

Data taken at site 109-018 (see Appendix A) were free of impulsive noise. However, 100 feet further along Watson Center Road strong impulsive noise conditions were observed which were associated with a 12 KV electric utility distribution line that terminated about 100 feet from the fixed measurement site. Figure 5-11 shows the impulsive noise encountered as the measurement van turned into a parking lot at the end of the distribution line, pulled away from the line during a wide turn in the parking lot, and then passed under the same line at a second parking lot entrance about 200 feet from the 109-018 site. The strong dependence of noise level on spatial movements is clearly shown. Additional impulsive noise measurements at a fixed location along Watson Center Road 100 feet from the actual 109-018 site are shown in Figures 5-12 and 5-13. The impulses are evenly spaced at about 2.6 ms intervals. Figure 5-12 shows variations in amplitude of the noise impulses over a 50 kHz wide band of frequencies and Figure 5-13 shows variations in amplitude over a 100 kHz wide band of frequencies.

1/23/79, 0944, from Del Amo onto Tillman
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

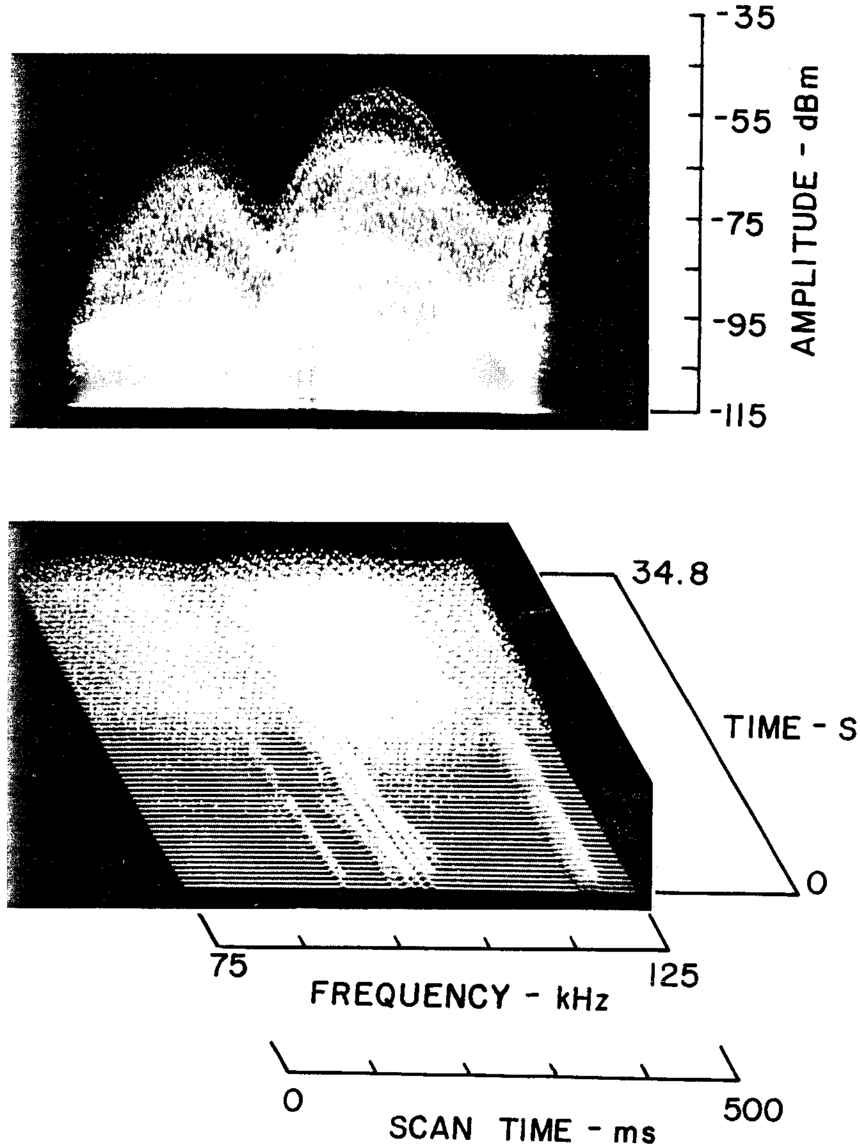


FIGURE 5-9. 3-AXIS VIEW, 1/23/79, 0944, FROM DEL AMO ONTO TILLMAN

1/22/79, 1125, Del Amo and Anza
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -30 dBm/0/+15 dB/NF

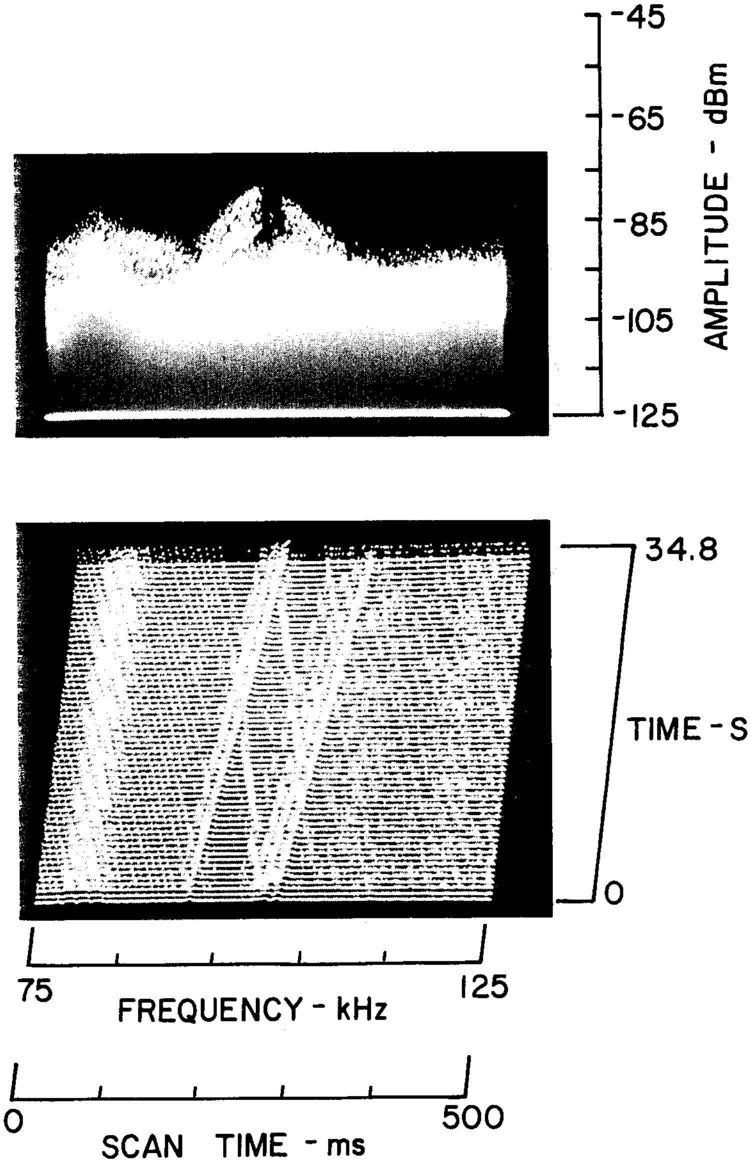


FIGURE 5-10. 3-AXIS VIEW, 1/22/79, 1125, DEL AMO AND ANZA

1/23/79, 0942, leaving 109-018 and u-turn under distribution line
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

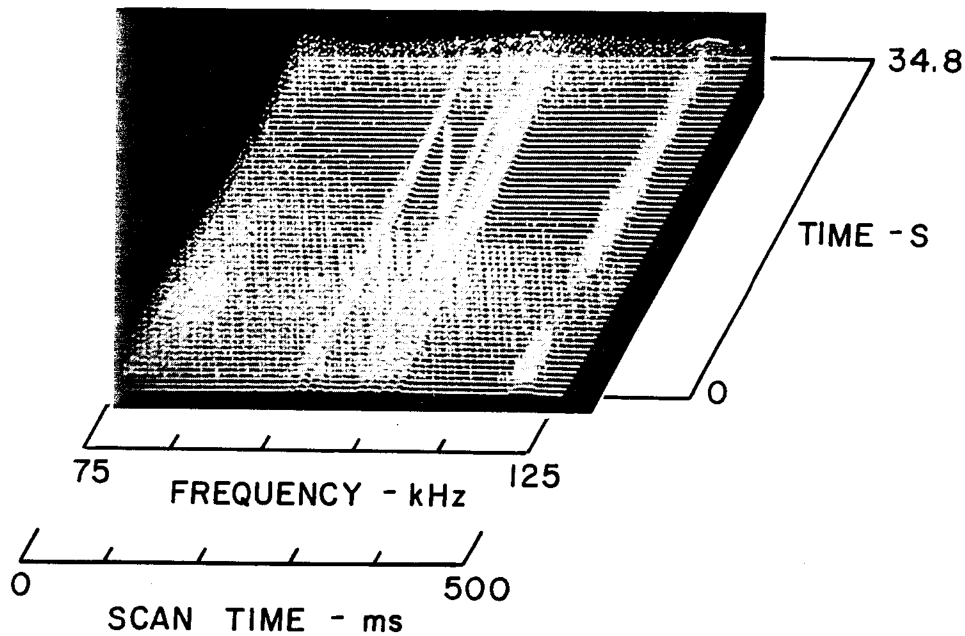


FIGURE 5-11. 3-AXIS VIEW, 1/23/79, 0942, LEAVING 109-018

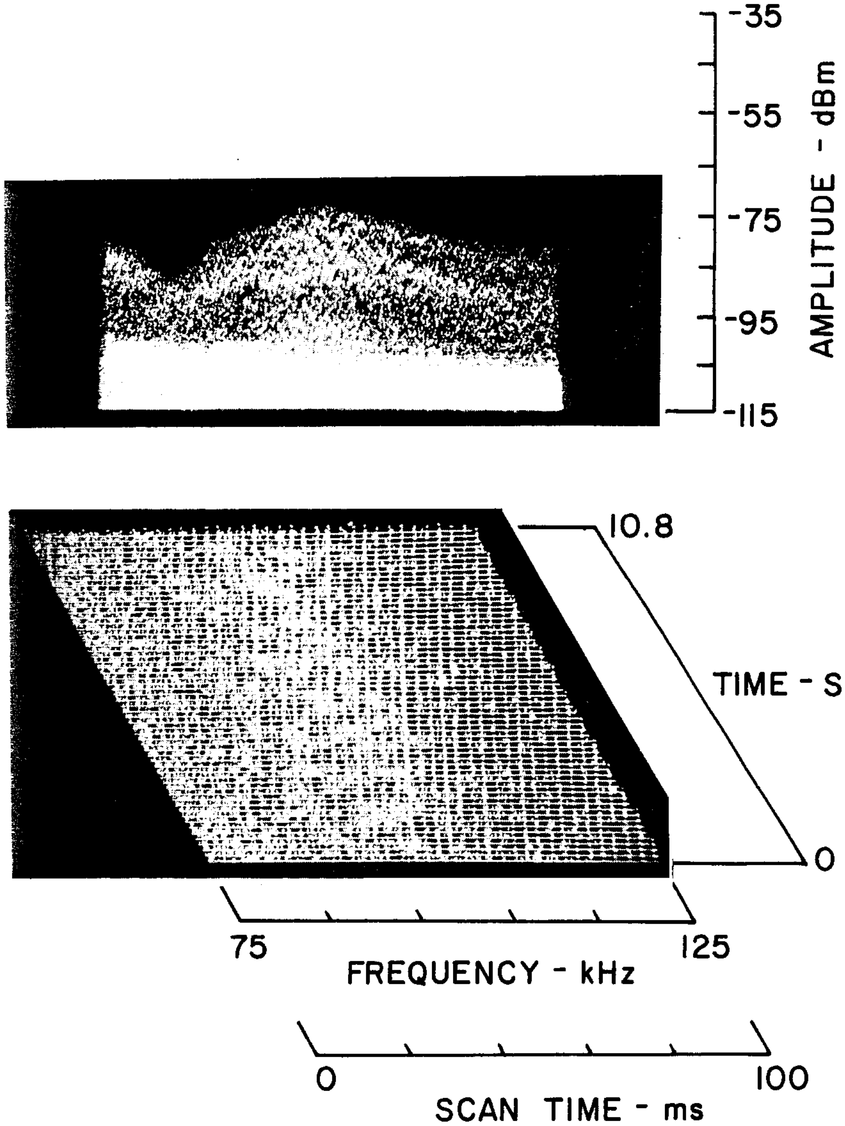


FIGURE 5-12. 3-AXIS VIEW, 1/26/79, 0920, 109-018 SITE 2

1/26/79, 0923, 109-018 Site 2
HP 140, Whip, F 100 kHz, W 100 kHz, IF 3 kHz, ST 100 ms, A -20 dBm/0/+15 dB/NF

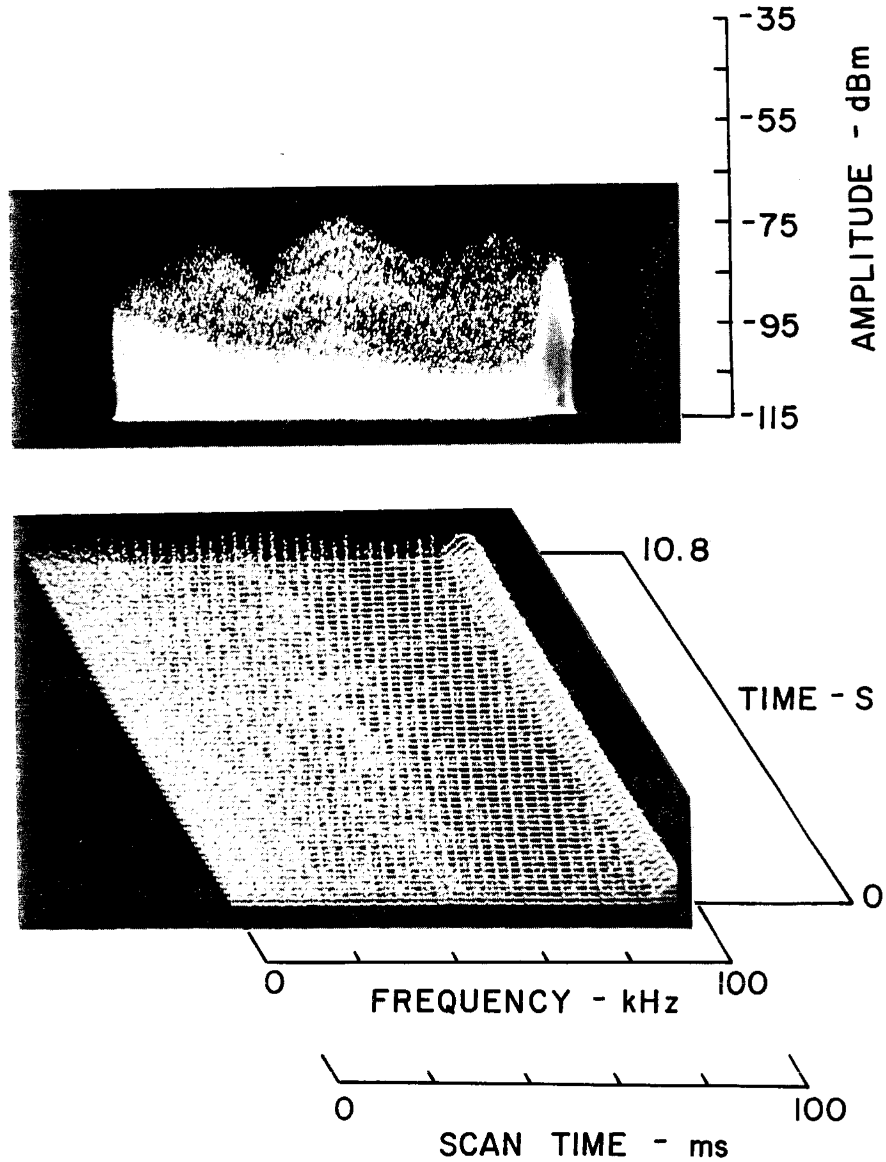


FIGURE 5-13. 3-AXIS VIEW, 1/26/79, 0923, 109-018 SITE 2

The top portion of the view in Figure 5-14 shows the lack of impulsive noise at site 109-018, while the bottom part of the view represents noise at the location used to obtain data in Figures 5-12 and 5-13. Figure 5-14 illustrates the critical aspects of site location and shows that drastically different noise conditions can be encountered only a few feet from a given site.

A nonuniform sequence of pulses emitted from a utility distribution line along Vista Del Mar is shown in Figure 5-15. The groups of two pulses are spaced 8.3 ms apart. The spacing between the two impulses is about 2 ms. Apparently, two separate switching devices were in operation with trigger points separated about 45° apart on the power line waveform.

1/26/79, 0930, Approaching 109-018 Site 2
HP 140, Whip, F 100 kHz, W 100 kHz, IF 3 kHz, ST 100 ms, A -20 dBm/0/+15 dB/NF

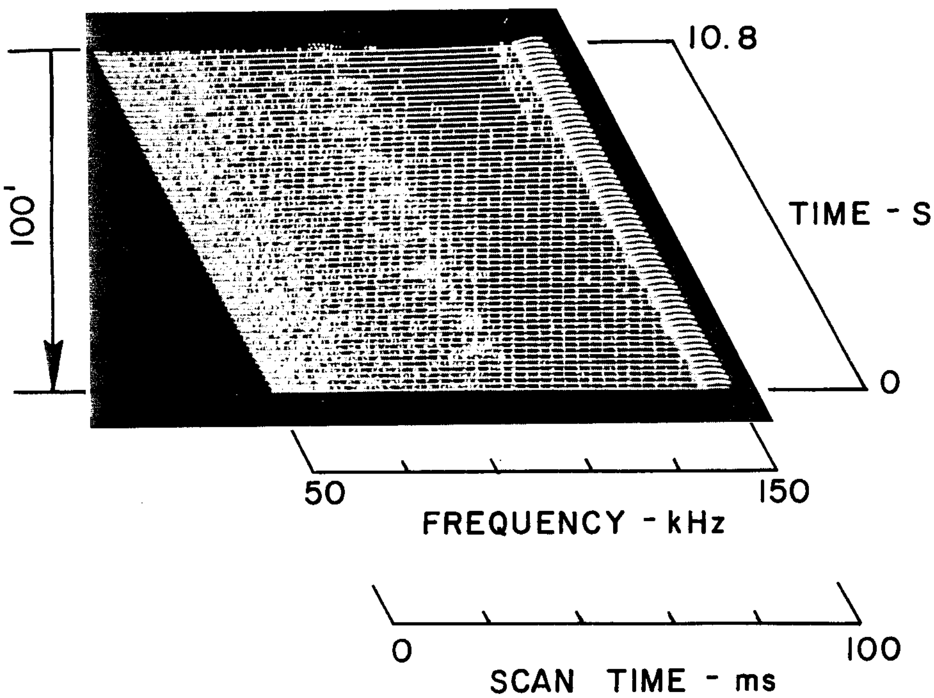


FIGURE 5-14. 3-AXIS VIEW, 1/26/79, 0930, 109-018 SITE 2

1/25/79, 1246, along Vista Del Mar south of El Segundo power plant
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 100 ms, A -20 dBm/0/+15 dB/NF

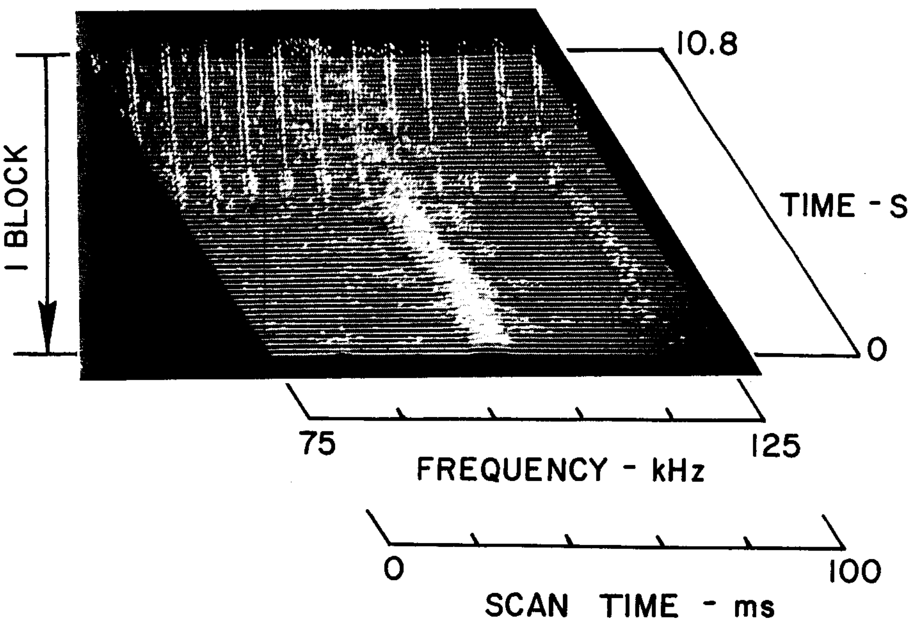


FIGURE 5-15. 3-AXIS VIEW, 1/25/79, 1246, VISTA DEL MAR

5.3.4 Time-Time Presentation of Impulsive Noise

Since the site near 109-018 provided orderly and high levels of impulsive noise with impulses spaced at even intervals of about 2.6 ms, the site was used to obtain time-time views. An example of a time-time view (receiver frequency scanning process stopped) is shown in Figure 5-16, where the top view shows 15 sequential groups of eight pulses from Station Y along with power line-emitted pulses spaced at intervals of about 2.6 ms. The second view from the top shows 16 lines of data taken from the top view. The third view from the top shows the bottom eight lines taken from the view immediately above. The bottom view shows the bottom four lines from the view immediately above. In the bottom view an eight-pulse Loran-C group from Station Y is shown on line 2, along with four power line-associated impulses which are within or near the Loran-C pulse groups. The amplitudes of the Loran-C and power line-associated impulses are nearly the same. Other similar situations can be identified in the other views showing additional scan lines. The views illustrate how power line-associated pulses and Loran-C pulses are mixed together, and how the two appear to a Loran-C receiver.

The time-time views show that the impulsive noise at site 109-018 was definitely not random in amplitude. The lower two views of Figure 5-16 indicate that most pulse amplitudes fell into two main amplitude levels (neglecting some minor variations) which had a very orderly repetitive pattern. Only very minor variations in amplitude were found from one day to the next day. The consistent amplitude pattern, along with the consistent spacing between impulses, indicates that the source mechanism was a very stable and orderly process.

1/26/79, 0855, 109-018 Site 2
HP 140, Whip, F 100 kHz, W T-T, IF 3 kHz, ST 20 ms, A -20 dBm/0/+15 dB/NF

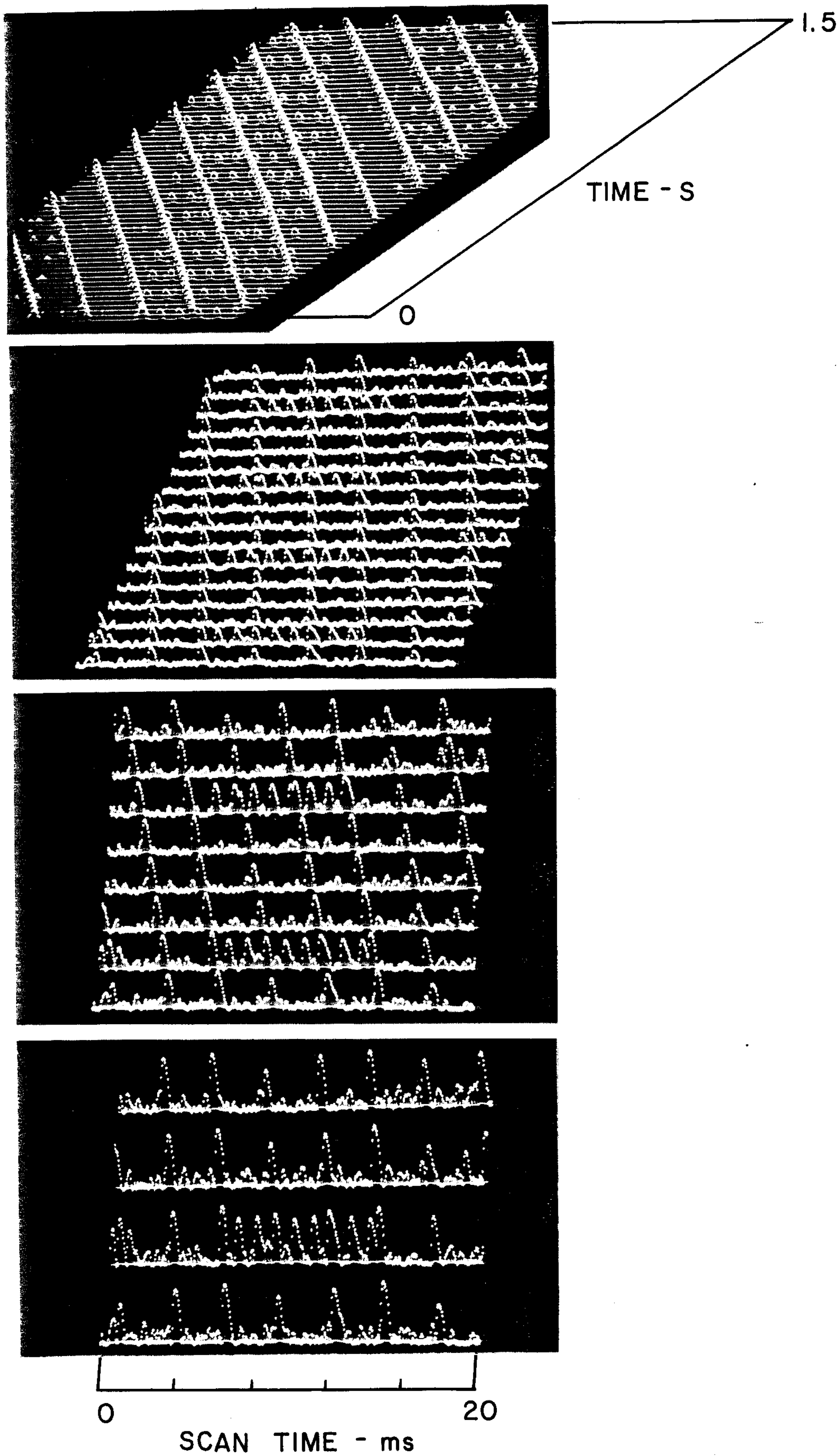


FIGURE 5-16. 3-AXIS VIEW, 1/26/79, 0855, 109-018 SITE 2

5.3.5 Traffic Control and Telephone Line Emissions

The Phase I measurements gave examples of CW signals which briefly appeared as the measurement van moved along a street. These brief bursts of CW signals were tentatively associated with street corners containing traffic control devices and with unshielded overhead telephone lines. Numerous cases of brief CW signals associated with street corners containing traffic control devices were again noted in the Phase II measurements. Examples are shown in Figures 5-17 and 5-18. While many of these signals from the Phase I effort were multiple frequency, the signals observed during the Phase II measurements were of single frequency. The data gave no indication of the reasons for this discrepancy, and there was inadequate time to investigate the sources in sufficient detail to determine why multiple and single frequencies were observed.

An example of a brief CW signal associated with an unshielded telephone line crossing the street in mid-block is shown in Figure 5-19. No other nearby structures were found which might be sources, and the signal peaked in amplitude when the measurement van was directly under the telephone line.

1/23/79, 1100, between 108-023 and 108-024 (traffic control signal)
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

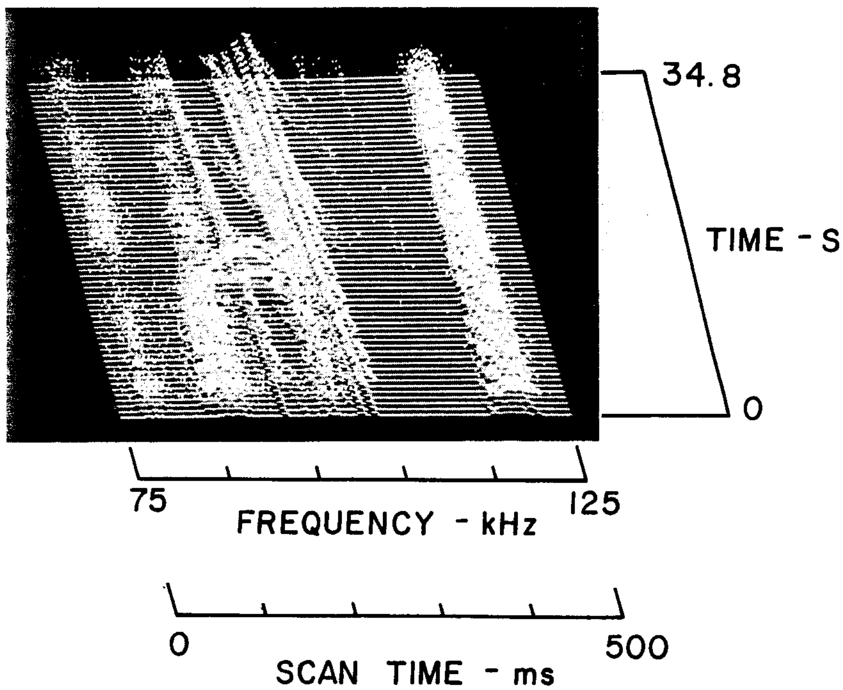
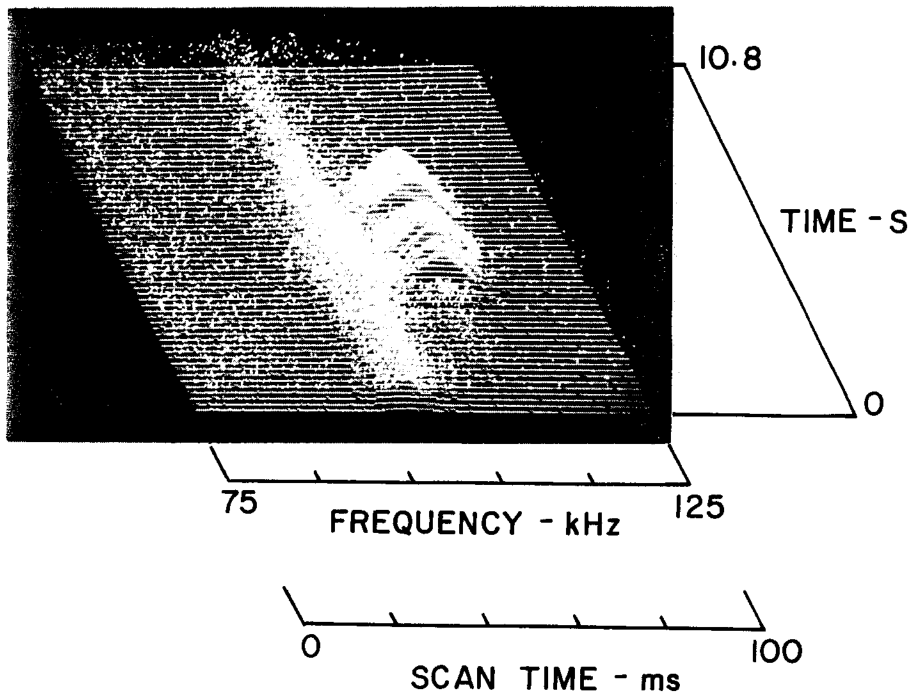
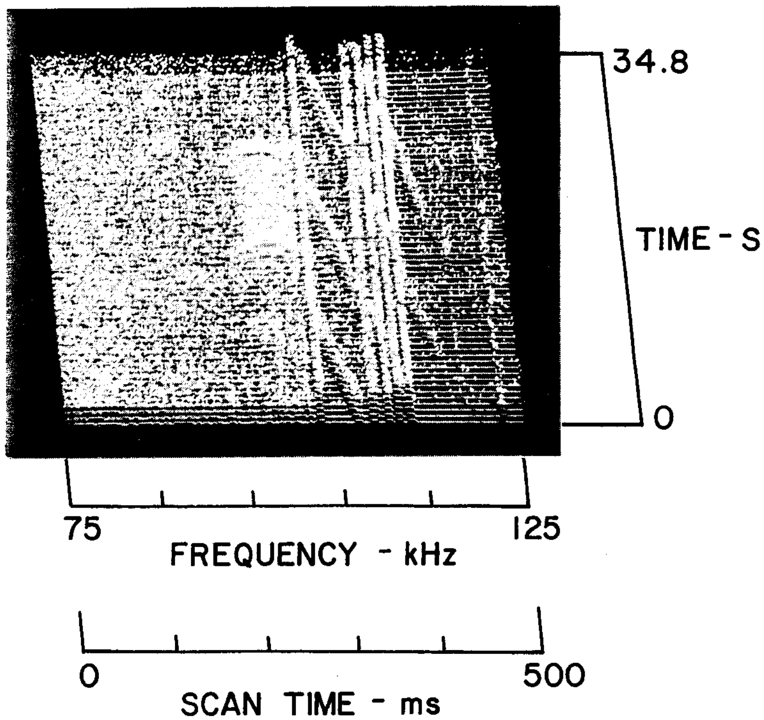


FIGURE 5-17. 3-AXIS VIEW, 1/23/79, 1100, BETWEEN 108-023 AND 108-024



1/26/79, 1211, Rosecrans & Sepulveda
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 100 ms, A -20 dBm/0/+18 dB/BPF

FIGURE 5-18. 3-AXIS VIEW, 1/26/79, 1211, ROSECRANS AND SEPULVEDA



1/26/79, 1156, passing under overhead telephone line, downtown El Segundo
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 500 ms, A -20 dBm/0/+15 dB/NF

FIGURE 5-19. 3-AXIS VIEW, 1/26/79, 1156, DOWNTOWN EL SEGUNDO

5.3.6 Ignition Noise

Ignition noise from nearby vehicles was noted during the Phase I measurements, but serious effects which might degrade Loran-C reception were not found. Cases of auto and truck ignition noise from nearby vehicles were again observed in the Phase II data, as shown in Appendix A at sites 109-015, 109-016, 108-029, and 104-052. These examples involved automobiles and trucks passing by and near (within about 20 feet) the measurement van. The examples seem to represent minor transitory noise of only minimal importance.

During the Phase II measurements a more noticeable type of ignition interference was present from a truck moving along a street parallel with the measurement van. When the truck was in a parallel lane of traffic and the engine area was in the vicinity of the whip antenna, consistent and longer duration ignition noise was observed, and ignition noise pulses occurred with amplitudes about equal to the Loran-C signals from Station Y. Two examples are shown in Figure 5-20. The curved lines show variations in the interval between ignition pulses as the truck engine RPM varied. At a highway speed of about 45 mph, the spacing from pulse to pulse was about 4 ms.

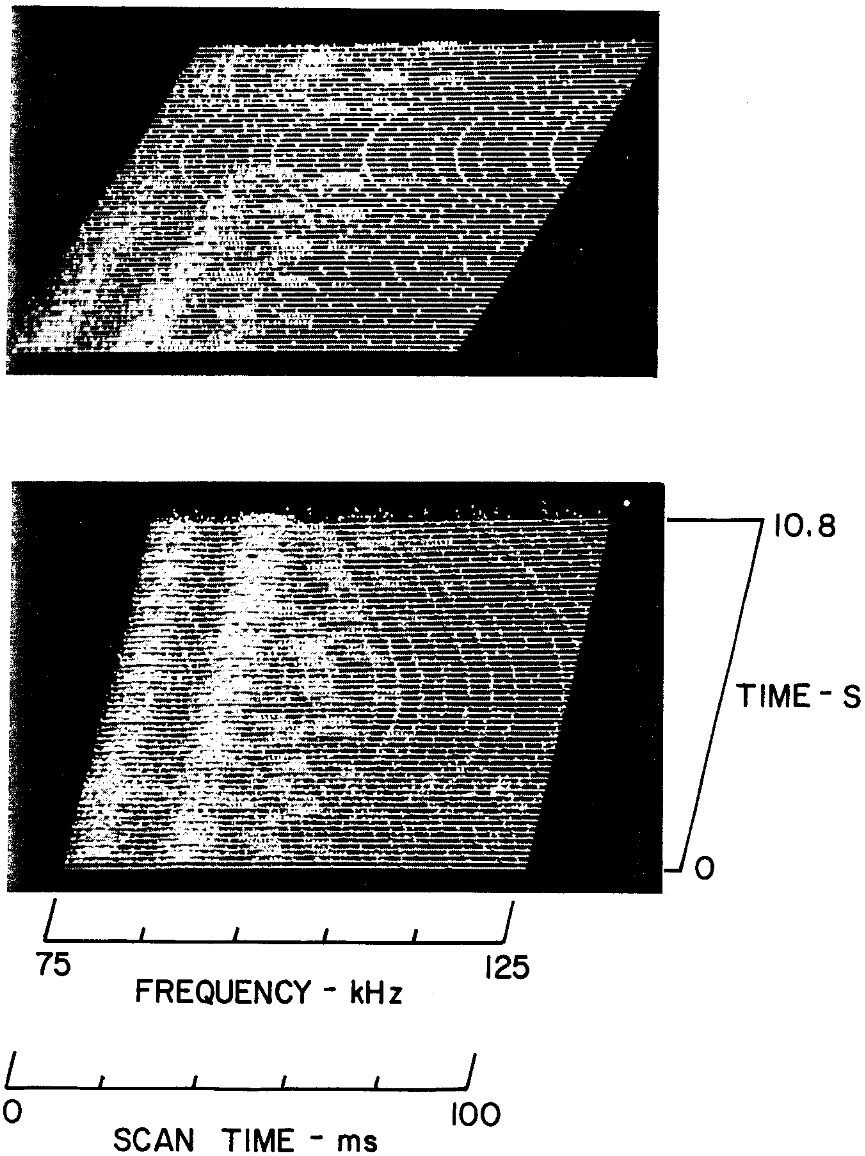


FIGURE 5-20. 3-AXIS VIEW, 1/26/79, 0803, HARBOR FREEWAY IGNITION NOISE

1/26/79, 0803, Harbor Freeway ignition noise (international truck)
HP 140, Whip, F 100 kHz, W 50 kHz, IF 3 kHz, ST 100 ms, A -20 dBm/0/+15 dB/NF

5.3.7 Freeway Effects

Brief decreases in the strength of Loran-C signals and CW signals were observed as the measurement van passed under a cross street and through an underpass. The attenuation of the signals from the underpass structure is shown in Figure 5-21, where the van was traveling on the Harbor Freeway in an area containing occasional overhead street crossings. Also, a brief burst of CW signal at 100 kHz can be seen in Figure 5-21 about 1/4 of the way from the bottom scan line. The CW signal was observed immediately after passing through the underpass, and it probably originated from a traffic control sensor on the overhead street.

Brief periods of impulsive noise were frequently observed when the measurement van proceeded along the freeway and traveled over a cross street on an overpass. An example is shown in Figure 5-22, where a burst of impulsive noise approximately two seconds long occurred. The noise probably originated from utility distribution lines along the cross street.